

Effects of ionizing radiation on the
chemical and isotopic composition
of the geologic outcrops on Mars.

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Ionizing radiation

- **Ionizing radiation:** GCR and SCR. GCR higher energies, does not change much. SCR up to 100s MeV, highly variable. Lya photon ~ 10 eV
- **Ionizing radiation:** is usually ignored because the the total energy of Solar UV is ~ 10000 times higher than the total energy of the cosmic rays
- **Ionizing radiation:** reached the Martian surface for **billions** of years due to thin Martian atmosphere and lack of magnetic field.
- **Ionizing radiation:** penetrates down to ~ 1 m into the solid rock (**unlike UV** and atmospheric oxidants)

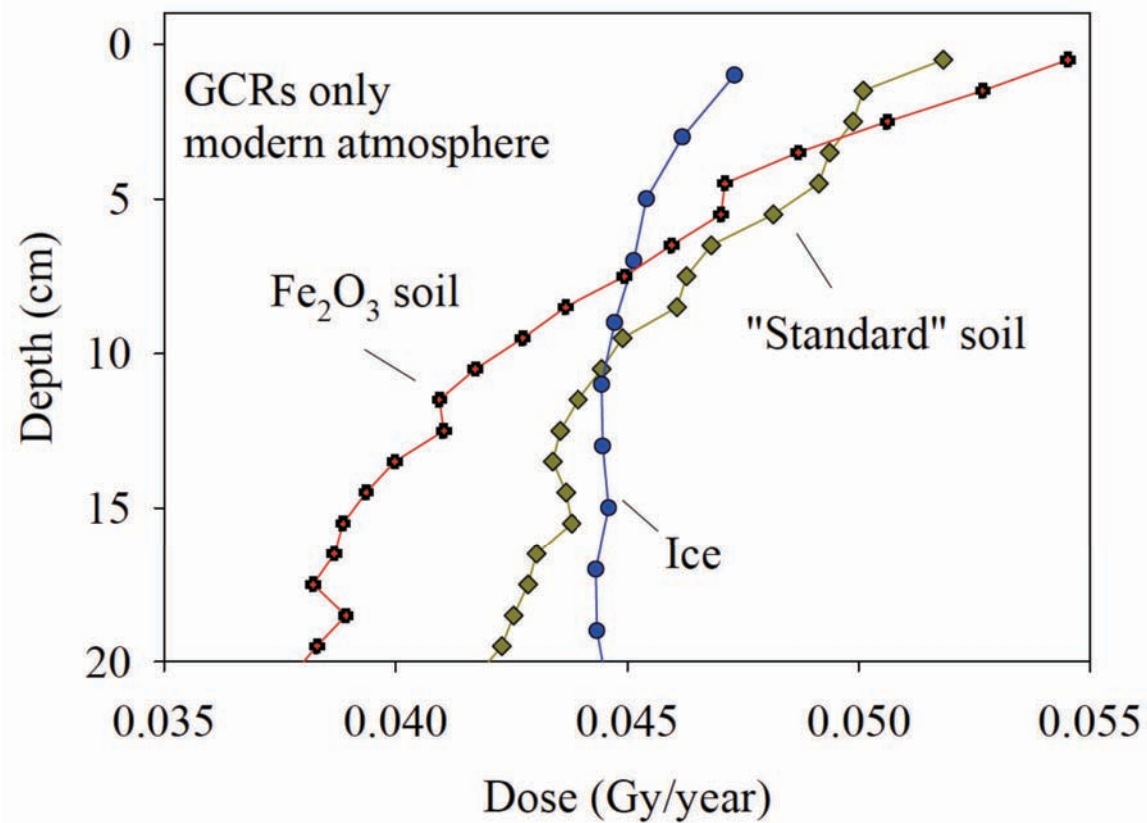
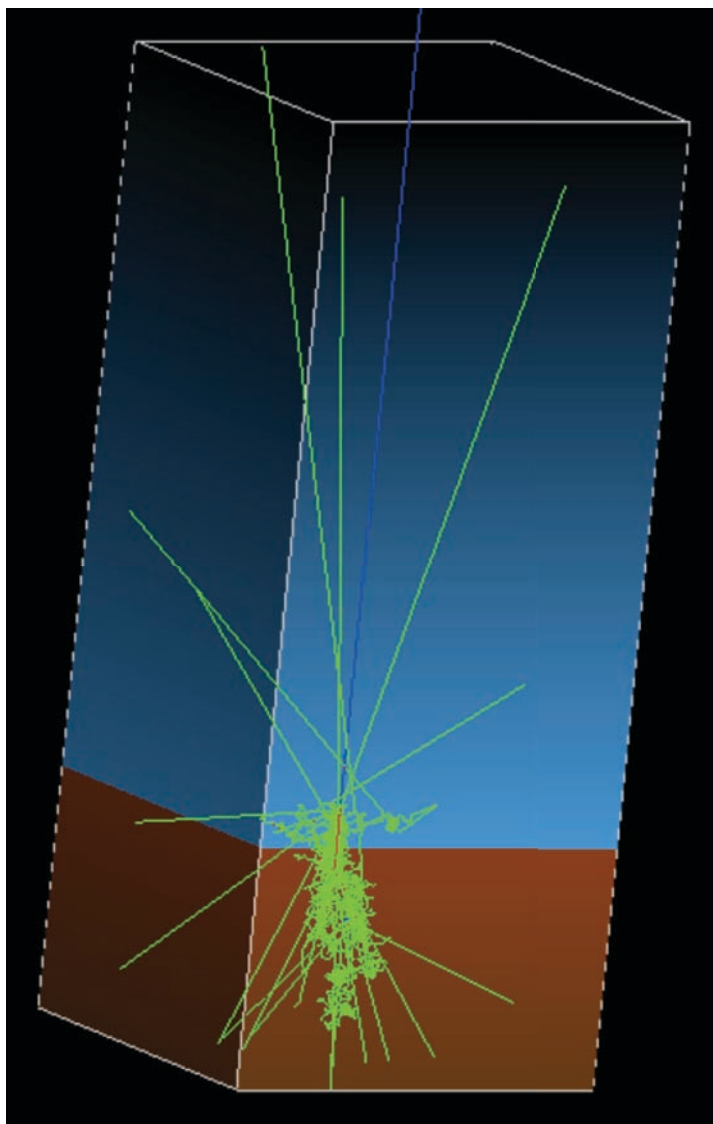


Figure 1: Depth profiles of cosmic ray dose rates for different materials and atmospheric conditions.

The graph illustrates the variation of cosmic ray dose rates with depth for four different scenarios.

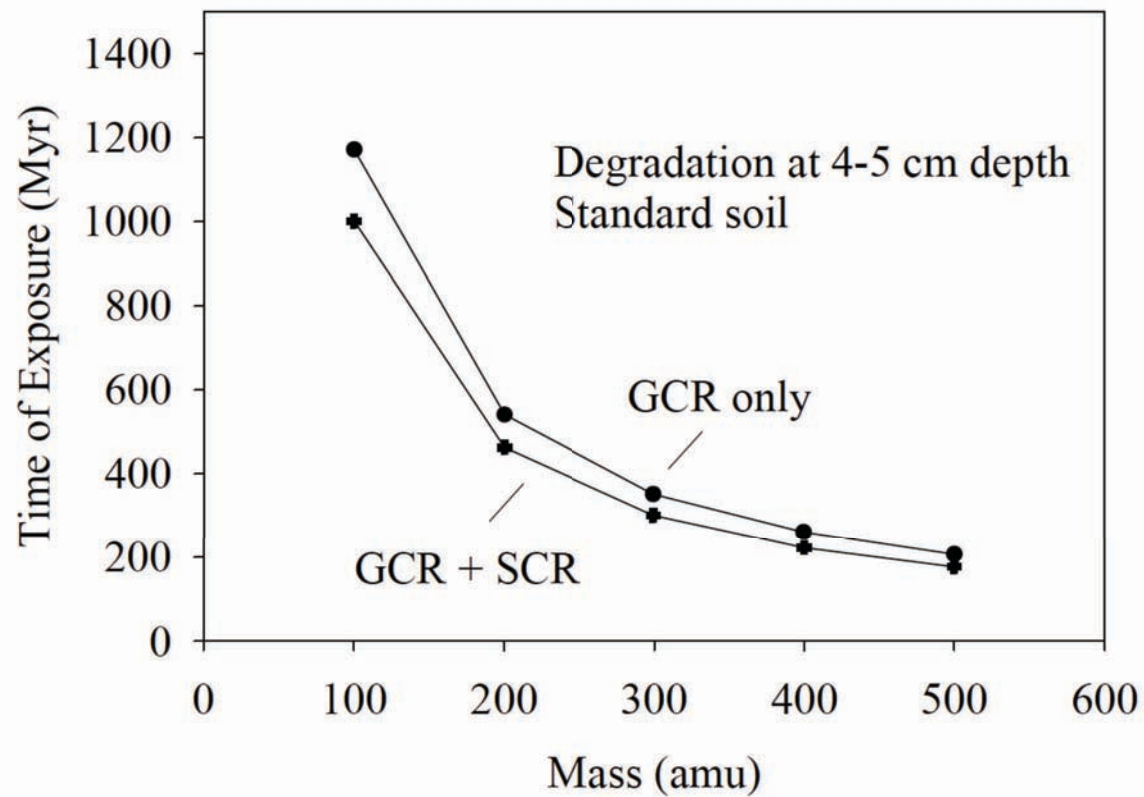
The 'Ice' scenario shows the highest dose rates, while the 'GCRs only modern atmosphere' scenario shows the lowest.

The 'Fe₂O₃ soil' and '"Standard" soil' scenarios show intermediate dose rates.

The dose rate decreases significantly with depth in all scenarios.

The 'Ice' scenario shows the most rapid decrease in dose rate with depth.

The 'GCRs only modern atmosphere' scenario shows the slowest decrease in dose rate with depth.



The graph shows the degradation of organic matter in standard soil at a depth of 4-5 cm. The x-axis represents the mass in atomic mass units (amu), ranging from 0 to 600. The y-axis represents the time of exposure in millions of years (Myr), ranging from 0 to 1400. Two curves are plotted: 'GCR only' and 'GCR + SCR'. Both curves show a decrease in exposure time as mass increases, with 'GCR + SCR' showing a steeper decline.

The degradation of organic matter in standard soil at a depth of 4-5 cm is shown. The x-axis represents the mass in atomic mass units (amu), ranging from 0 to 600. The y-axis represents the time of exposure in millions of years (Myr), ranging from 0 to 1400. Two curves are plotted: 'GCR only' and 'GCR + SCR'. Both curves show a decrease in exposure time as mass increases, with 'GCR + SCR' showing a steeper decline.

$^{12}\text{C}/^{13}\text{C}$ ratio

- Natural abundance: ^{12}C ~99%; ^{13}C ~1%
- Ratio important for identification of the source of organic matter
- Both ^{12}C and ^{13}C can be produced in spallogenic reactions on ^{16}O
- Long exposure would cause “heavy” organic matter

Conclusions

- Destruction of complex organic matter in the top 5-10 cm of soil by the ionizing radiation cannot be neglected if the age of exposure is > 200 Myr
- $^{12}\text{C}/^{13}\text{C}$ will become “heavy” due to production of ^{13}C by the ionizing radiation in the soil if the total carbon content is in ppm range

Suggestions for the outcrop selection

- Seek outcrops with fresh (<100 Myr old craters) craters
- Seek outcrops with “high” erosion rates (~10 nm per year)
- SCRs effects can be effectively eliminated by choosing outcrops at lower elevations